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THE RELATION OF THE NUMBER OF BACTERIA IN MILK TO THE QUALITY AND YIELD OF CHEESE

G. J. HUCKER

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BULLETIN No. 486*

THE RELATION OF THE NUMBER OF BACTERIA IN MILK TO THE QUALITY AND YIELD OF CHEESE

G. J. HUCKER

SUMMARY

In order to determine the significance of the quality of milk used in the production of cheddar cheese as determined by the number of bacteria present, a series of observations were made at a cheese factory during the summer of 1920. A record of the bacterial count of the milk, both as received at the factory and in the making vat, was kept and a study made of the relation between the quality of the milk and the quality and yield of the cheese.

Sample cheeses were retained and scored. These scores were then compared with the number of bacteria in the milk as determined either by actual count under the microscope or by using the acidity of the milk as an index of the number of bacteria present. No striking relation was found to exist, altho it was observed that milk containing from 12 to 42 million bacteria per cc. produced a cheese of more constant quality than did milk containing a smaller number of organisms.

The yield of cheese in each vat was computed daily and compared with the number of bacteria present in the milk. In the series of observations made, variations in the yield of cheese showed no evident relationship to variations in the number of bacteria in the milk.

It is concluded that the present method of grading market milk on the basis of the total number of bacteria present is not applicable to the grading of cheese milk. The specific types of bacteria present in the milk are far more important than the total number present.

INTRODUCTION

New York State has long had an enviable reputation for the high quality of its market milk, largely because of the enforcement of standards of quality based upon the number of bacteria present in the milk and on an inspection of the premises where the milk is produced. Because a tendency is developing in the State to employ the same standards in judging milk used for making cheese as those now in force for market milk, this Station undertook, during the summer of 1920, a study of the relation between the number of bacteria present in cheese factory milk and the quality and yield of the cheese produced. The results obtained, while not extensive, throw some light on the complex relationships involved and are summarized in the present bulletin.

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*This bulletin is the first of a series of papers, to be issued by the Station, dealing with the bacteriological aspects of cheese ripening and its relation to milk flora. Subsequent publications will follow as the work is completed.

SOURCE OF DATA

The data used in this study were collected at the factory of F. X. Baumert and Co. located 4 miles east of Philadelphia, N. Y., and known locally as "Halls Corners." This factory is typical of the American cheddar cheese factories of the State and has a comparatively new, well-painted building. The equipment was of the usual type consisting of two vats, sterilizing tubs, etc. The building was divided into four rooms used for making, boiler, curing, and paraffining and packing rooms, respectively. All the rooms have concrete floors. The factory is situated on a well-drained lot near a small creek which serves to carry away wastes.

Only full cream cheddar cheese of the Young America type had been made at this factory for a number of years. The curd was not washed and the cheeses were usually kept on the shelves for about two weeks before shipping.

The factory received milk from 25 dairies in 7 of which milking machines were used. The majority of these dairies were visited and found to be typical of cheese districts. Some of the dairies were poorly kept and the milk was not cared for in a cleanly manner, while others were conducted with care and a clean product obtained. The milk was drawn to the factory in 50 gallon cans and each farmer was responsible for cleaning his own cans.

The whey from the vats was jetted by means of a steam pump into a tank in the attic of the factory and after running thru a separator by gravity, ran into a wooden tub whey tank situated about 20 yards away from the factory. The outside tank was covered and the farmers pumped the whey from the vat into their cans. The whey tank was thoroly cleaned every week and the auxillary tank in the attic was washed and scalded each day.

TECHNIQUE

Samples from weigh-can.— Samples of each patron's milk were taken as soon as the milk was emptied into the weigh-can. The sample was a composite of both night and morning milk. Duplicate preparations of milk for staining for examination under the microscope were made immediately and a sample was also titrated as described below. One preparation was stained with methylene blue and the other with a modification of the usual Gram stain.[1]

In making counts with the microscope by the Breed[2] method, ten fields were examined from each preparation, and the counts used in this bulletin are the average of the two. As the microscope was so adjusted that the dried milk solids from 1/300,000 cc. of milk were visible in each field of the microscope, the total amount of milk examined in each case was 1/15,000 cc.

It is to be noted that the counts used in this bulletin are counts of individual bacteria as seen under the microscope and not the usual plate counts. If the latter had been used the counts would have been much lower.

In titrating for apparent acidity, 9 grams of milk were taken and, after adding a few drops of phenolphthalein, titrated with 0.1 N NaOH. Each 0.1 cc. of alkali used represented 0.01 per cent acid in the milk.

Samples from the making vat.— Milk samples were also taken from each of the two vats immediately before the addition of the rennet. These samples were subjected to the same routine examination as those taken from the weigh-can.

Sample cheeses.— Sample cheeses were taken from each vat, parraffined, and stored for future scoring. These cheeses were kept in the curing room of the factory for a month and were then placed in cold storage. In October they were forwarded to Geneva and scored by Mr. G. A. Smith, Dairy Expert of this Station, and by Mr. R. R. Kirkland and Mr. H. A. Rees, Cheese Instructors from the New York State Department of Agriculture.

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[1] Hucker, G. J. A modification and a new application of the Gram stain. *Abst. Bact.* 5: *No. 1. 1921.*

[2] Breed, R. S. and Brew, J. D. Counting bacteria by means of the microscope. *N. Y. Agr. Exp. Sta. Tech. Bull. No. 49. 1916. Also Circ. No. 58 of this Station.*

DATA

The results obtained are presented in graphic form. In these graphs the number of bacteria in the milk, both as received at the factory and in the making vat, have been compared with the quality and yield of the cheese. Similar comparisons have also been made between the acidity of the milk as received and in the vat and the quality and yield of cheese. In each graph the quality or the yield is represented by the abscissa and the acidity or bacterial count of the milk by the ordinate.

It is to be noted that these observations were made on a limited number of vats of milk (60), and from one factory only. It is believed, however, that the conditions noted are typical of other similar factories.

QUALITY OF CHEESE

Relation of the number of bacteria in patrons' milk as received at the factory to the quality of the cheese.— The patrons' milk was found to vary in bacterial content from 220,000 to 41,400,000 per cc. when received at the factory. A few somewhat obscure correlations appear on examination of Chart I. It will be noticed, for example, that milk received at the factory with a count of less than 12,000,000 bacteria per cc. produced cheese with a wide range in quality. Both the highest and lowest scoring cheese was made from milk of this class. Milk received at the factory with a count of more than 12,000,000 bacteria per cc. and less than 42,000,000 per cc. produced cheese that scored between 94.5 and 96 per cent on the scale used. In other words, none of the ten cheeses in this group were of the highest quality and none were of the poorest quality.

A possible explanation of this condition is suggested in the fact that the cheese maker exercised some selection in the case of very high-count milk, rejecting patrons' milk which he regarded as undesirable. Milk with an evident acid odor was accepted, however, and it is milk of this type which undoubtedly contained the largest number of bacteria. It is well known that a milk with detectable acid odor, if not too acid, can be made into good cheese.

Even if the above is not the true explanation of the findings, the highest count milks received are usually those which have not been properly cooled and the bacteria which overgrow all other types under such conditions are generally of the lactic acid group.

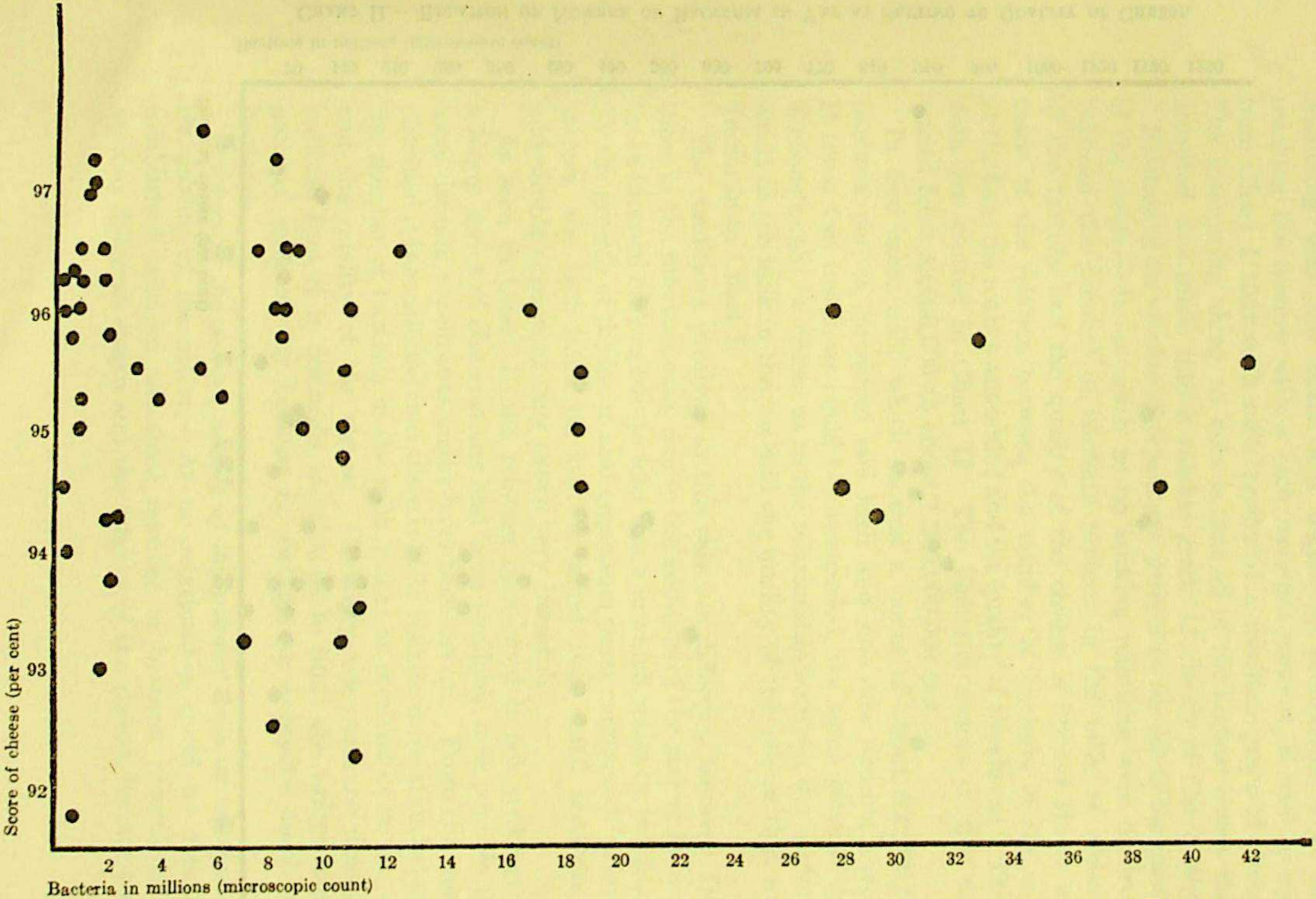

Chart I.— Relation of Number of Bacteria in Milk as Received at Factory to Quality of Cheese.

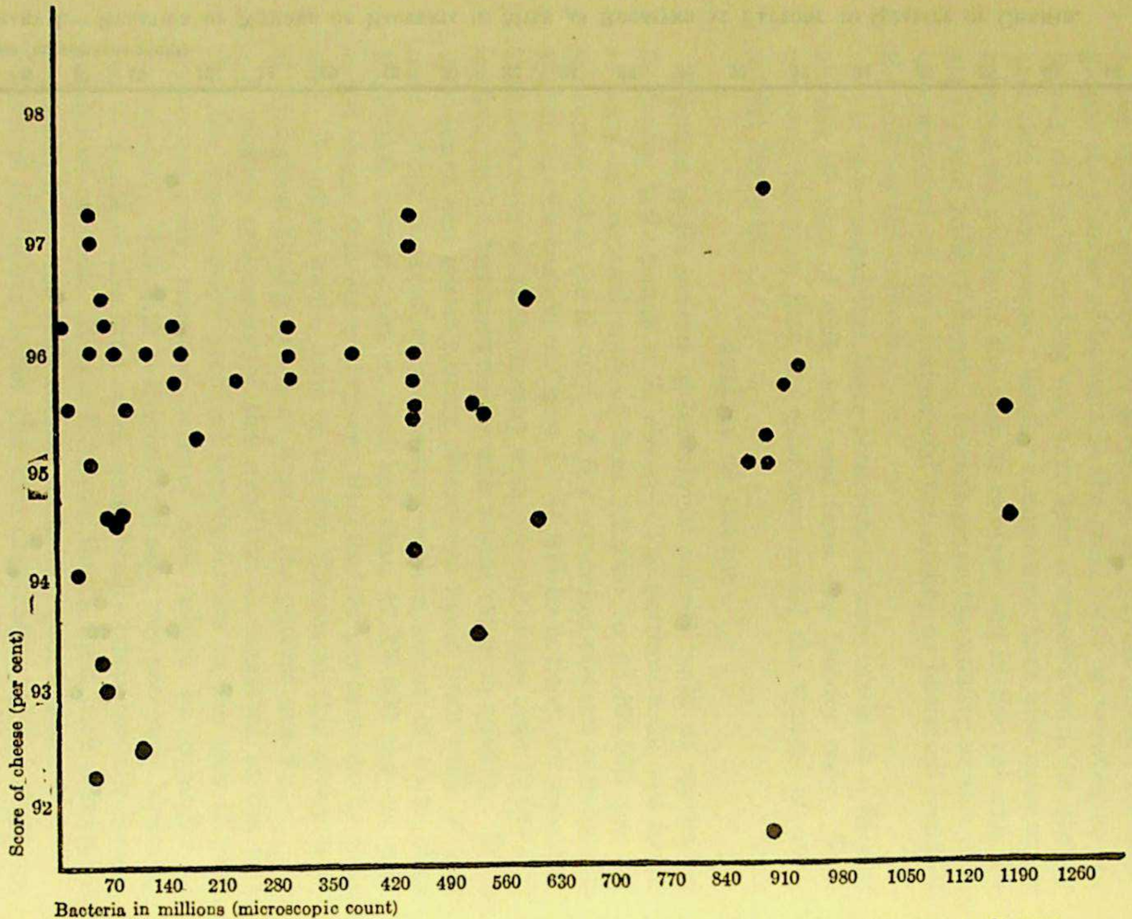

CHART II.— RELATION OF NUMBER OF BACTERIA IN VAT AT SETTING TO QUALITY OF CHEESE.

Assuming that the lactic acid organisms predominated in milk reaching the factory with a high bacterial content, it will be seen from Chart I that such milk produced a medium grade of cheese. The interesting thing to note is that *all* of the highest count milk accepted was made into a salable grade of cheese of fair quality.

Relation of the number of organisms present in the vat to the quality of the cheese.— In as much as no striking relations were observed between the number of bacteria present in the milk as received at the factory and the quality of the cheese, a further study was made of the relation between the number of bacteria in the milk at the time the rennet was added and the quality of the cheese. These data are plotted in Chart II. The bacterial counts in this case varied from 12,000,000 to about 1,200,000,000 per cc.

In two cases milk which showed a count of about 900,000,000 bacteria per cc. produced one high and one low scoring cheese. If these two instances could be disregarded, the same general conclusions might be drawn as to the relationship between the bacterial count of the milk in the vat and the quality of the cheese that were drawn from Chart I.

The conditions involved in this case are different, however, from those in the previous case, due to the addition of the starter followed by an interval of from two to four hours in which optimum conditions for the growth of the lactic acid organisms were maintained. Nevertheless, the fact must be kept in mind that small numbers of undesirable organisms may prove very harmful.

As seen in Chart II the relation mentioned is not striking. If a larger series of observations had been available it is possible that more definite conclusions might have been drawn. From the results obtained it is concluded that there is little definite correlation between the number of bacteria in the milk, either as received or in the vat, and the quality of the cheese. Certainly the evidence does not indicate that it is desirable to attempt to limit the acceptance of patrons' milk simply because it contains an excessive number of bacteria.

Relation of the average acidity of the patrons' milk as received and the quality of the cheese.— As no relationship could be definitely established between the total number of bacteria present in the milk at different stages and the quality of the cheese, further observations were made upon the apparent acidity of the patrons' milk and its relation to the quality of the cheese.

The acidity of the milk is a rough index of the number of bacteria present. In fact the acidity test has been used at condensaries as a means of detecting milk unfit for condensing. The milk as received at the factory under observation was found to have a higher acidity than has generally been reported from cheese factory milk, a condition produced by the large number of bacteria in the milk. The data obtained have been plotted in Chart III. The results tend to group around artificial centers because of the fact that the titrations were usually read in whole numbers.

It can be readily seen from the data presented that such variations in the acidity of the patrons' milk as were observed have no influence on the resulting quality of the cheese. Acidity tests on patrons' milk are clearly still less applicable at cheese factories than at condensaries.

Since cheese ripening is largely dependent upon bacterial action, the acidity of the milk could be valuable only in approximating the count which, as stated above, is of little value in judging the quality of cheese factory milk.

Relation of the acidity of the vat to the quality of the cheese.— When no correlation was found between the acidity of the patrons' milk and the quality of the cheese, the importance of the acidity of the vat at setting suggested itself as a possible factor affecting the cheese quality. The amount of acid in the vat at setting was found to vary greatly from day to day dependent upon the will of the cheese maker and the condition of the milk. The chief factor in the control of milk which became heavily contaminated with an undesirable flora was the development of acid in the vat and, such being the case, the amounts allowed to develop varied from 0.18 to 0.28 per cent. No correlation could be found in the results obtained as shown in Chart IV.

The grouping of the results around certain areas in the chart can be explained by the fact that a high acidity was allowed to develop if the milk was suspected to contain large numbers of gas producing bacteria as the growth of this group is checked in the presence of excessive acid. Excessive acid also favors the growth of yeast which may result in as poor quality of cheese as in cases where the gas producing organisms are not controlled with high acidity.

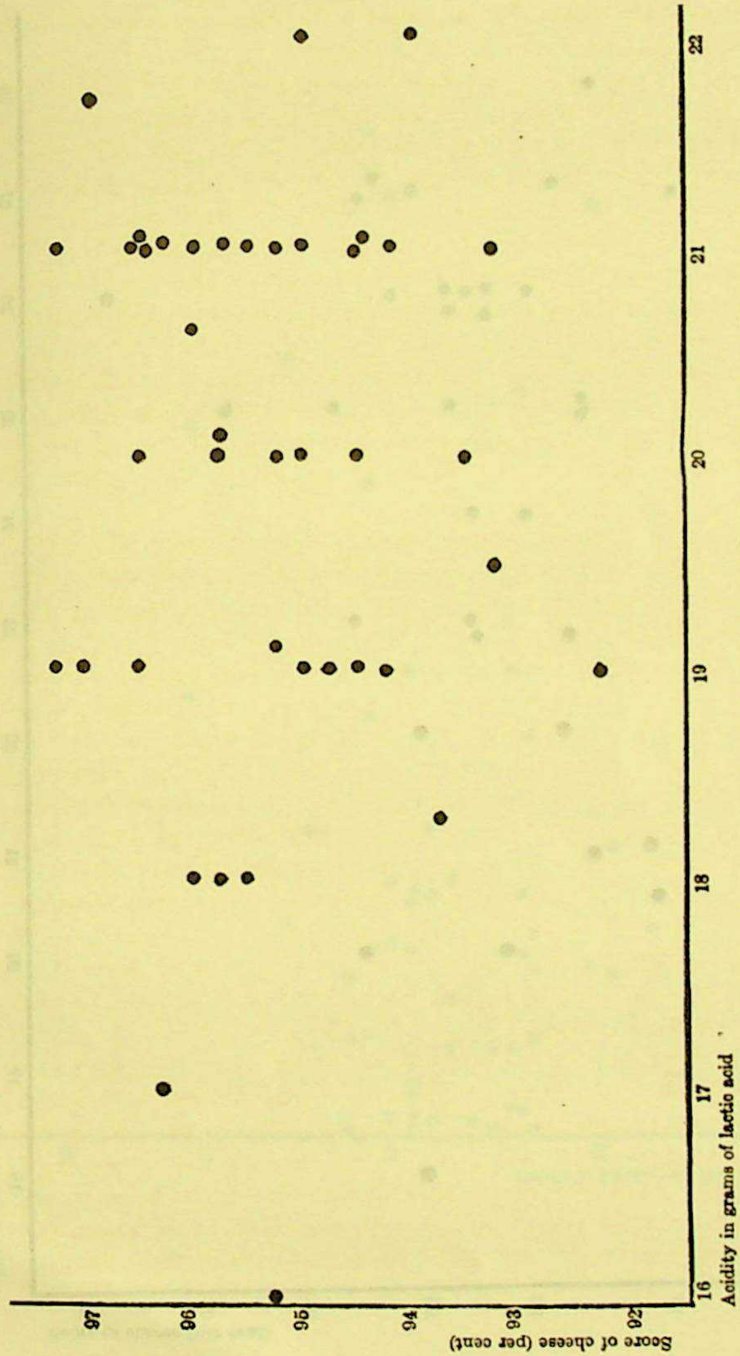

Chart III.—Relation of Average Acidity of Milk to Quality of Cheese.

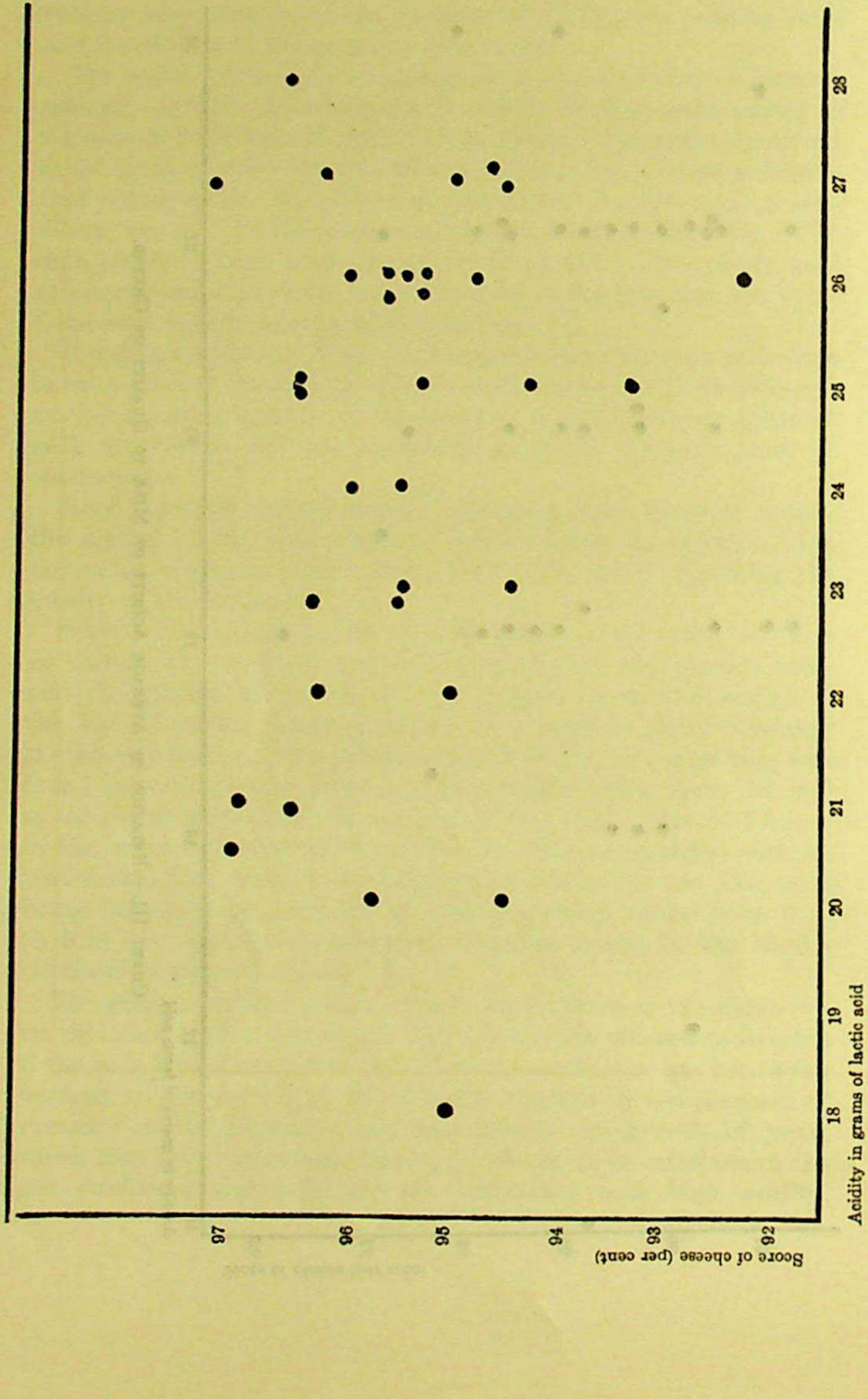

CHART IV.— RELATION OF ACIDITY OF VAT AT SETTING TO QUALITY OF CHEESE.

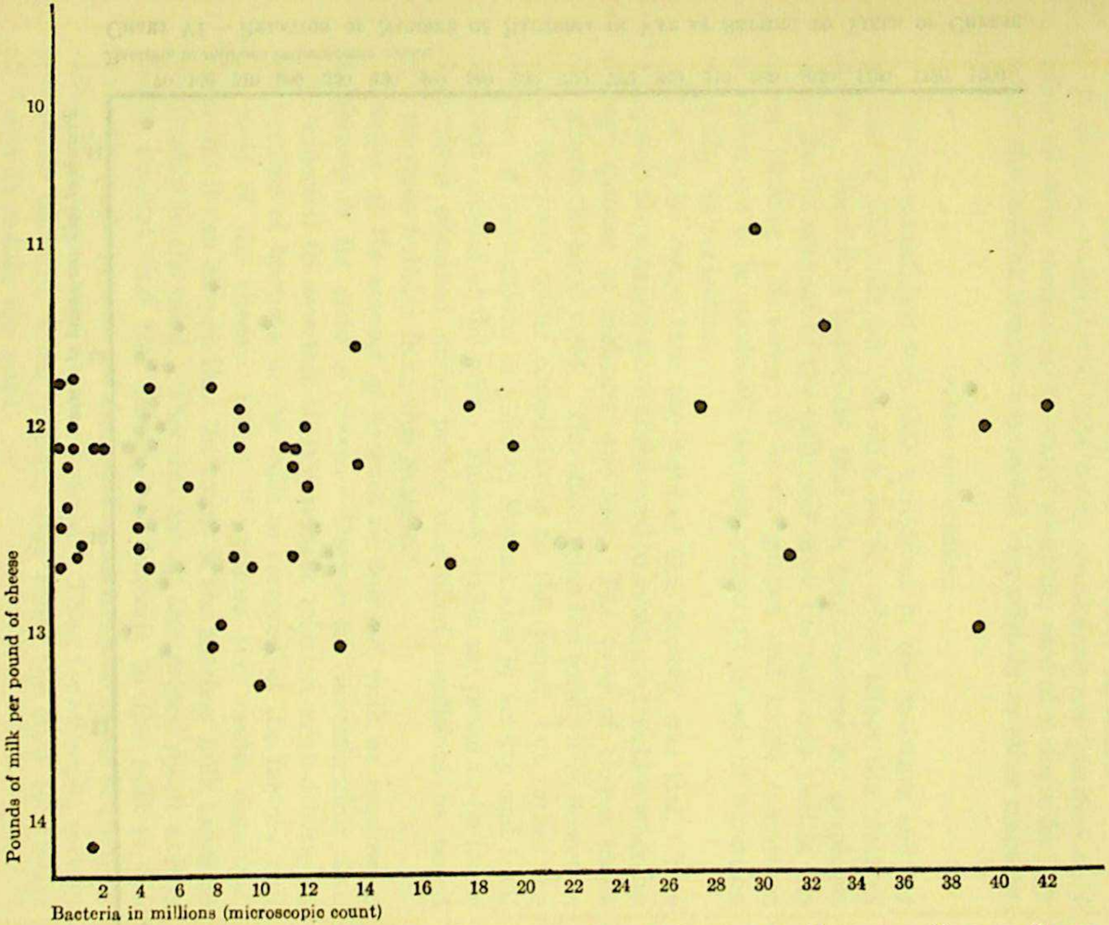

CHART V.—RELATION OF NUMBERS OF BACTERIA IN MILK AS RECEIVED AT FACTORY TO YIELD OF CHEESE.

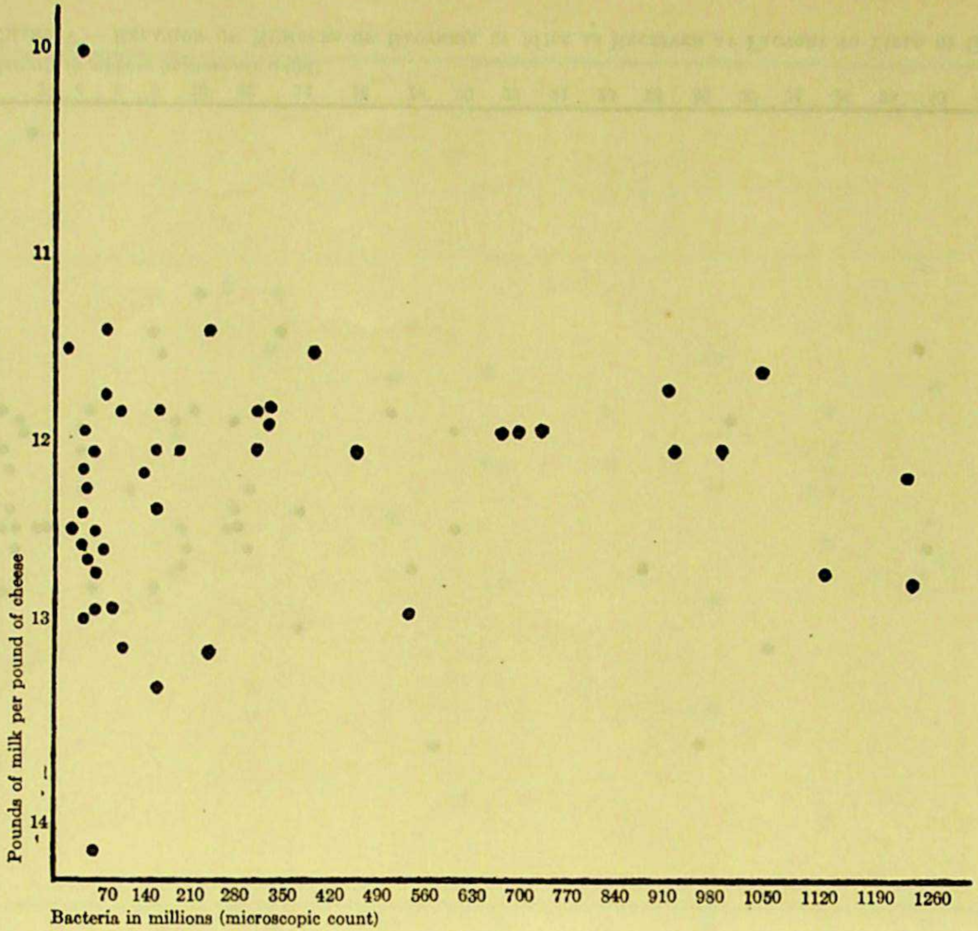

CHART VI.— RELATION OF NUMBER OF BACTERIA IN VAT AT SETTING TO YIELD OF CHEESE.

Because of these conditions the appearance of high and low scoring cheese from milk of high acidity can be readily explained.

It is to be remembered that these conclusions are justified only when all other conditions are equal as in the case of a single factory where the making process was varied very slightly in other respects.

YIELD OF CHEESE

It is an established fact that variations in the moisture and fat content of the milk are the *chief* factors which affect the yield of cheese. Thus it is important that the manufacturer lay emphasis upon the fat content of the milk and upon the methods used in the cheese making. However, if better grades and larger quantities of cheese are to be produced, the less important causes of variation must also be controlled.

It is to be noted that the yield of this factory was low. This was due to the manipulation of the curd to avoid gas troubles whereby a large amount of moisture was lost. The type of cheese made also affects the total yield. The effect upon the total yield, however, is not the point under consideration in this paper, but rather the relation of fluctuations in yield to fluctuations in acidity and total bacterial content of the milk. Factory yields are prone to be lower than those obtained under better controlled conditions as noted in a previous bulletin from this Station.[3]

Relation of the number of bacteria in patrons' milk as received at the factory to the yield of cheese.— During the investigation data were collected to ascertain if any evident relation existed between the number of bacteria in the milk as received at the factory and the yield of the cheese. Chart V outlines the results obtained. From this it can be seen that the count of the patrons' milk bears no relationship to the yield. This was not an unexpected result as it is clearly evident that the influence of bacteria in the milk is due primarily to the presence of desirable or undesirable types of bacteria rather than to the total number present. Thus, for example, certain proteolytic bacteria, when present, may cause the curd to " whey off " and so reduce the yield.

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[3] Summary of results of experiments made in the manufacture of cheese during the season of 1892. *N. Y. Agr. Exp. Sta. Bul. No. 50. 1893.*

Relation of the number of bacteria present in the vat to the yield of cheese.— The results obtained were studied to ascertain if any relation existed between the bacterial content of the milk in the vat and the yield of cheese. In the series of observations made no such relationship could be established as shown by the graphic representation of the results in Chart VI.

Relation of the average acidity of the milk as received at the factory to the yield of cheese.— As in the previous comparison between the bacterial count and yield no definite relationship could be found between the acidity of the milk as received and the yield. (See Chart VII.) The same grouping around artificial centers is noted in these results as in the case of Chart III. These groupings are due to the fact that the titrations are usually read in whole numbers. This conforms to the usual factory and condensary procedures.

Relation of the acidity of the vat to the yield of cheese.— Chart VIII shows clearly that, in general, the yield does not fluctuate with varying acidity of the milk in the vat. This is not surprising as the acidity at the time of setting had little, if any, relation to the final acidity that was allowed to develop. These findings are in accord with those previously noted by Dean [4] who states that " there was very little difference in the yield and quality of the two lots — one set at 0.21 and the other with an average of 0.177 per cent acid."

CONCLUSIONS

It is evident from the results obtained that, within the ranges noted, the number of bacteria present in milk as received at cheese factories is no indication as to its quality for cheese making. The quality of the cheese did not fluctuate with variations in the total bacterial content of the milk. The only relationship which appeared constant was that the milk which contained the largest number of organisms tended to produce a cheese of fair quality and constant grade, while all cases of comparatively low count milk were found to produce cheese of grades varying between the two extremes of the scale used for scoring. This relationship was not striking as the range in the quality of the cheese was not wide and the number of cases noted were limited. It was also observed that the

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[4] Dean, H. H. Cheddar cheese experiments and investigations. *39th Ann. Rpt. Ont. Agr. Col. and Expt. Farm, 76. 1914.*

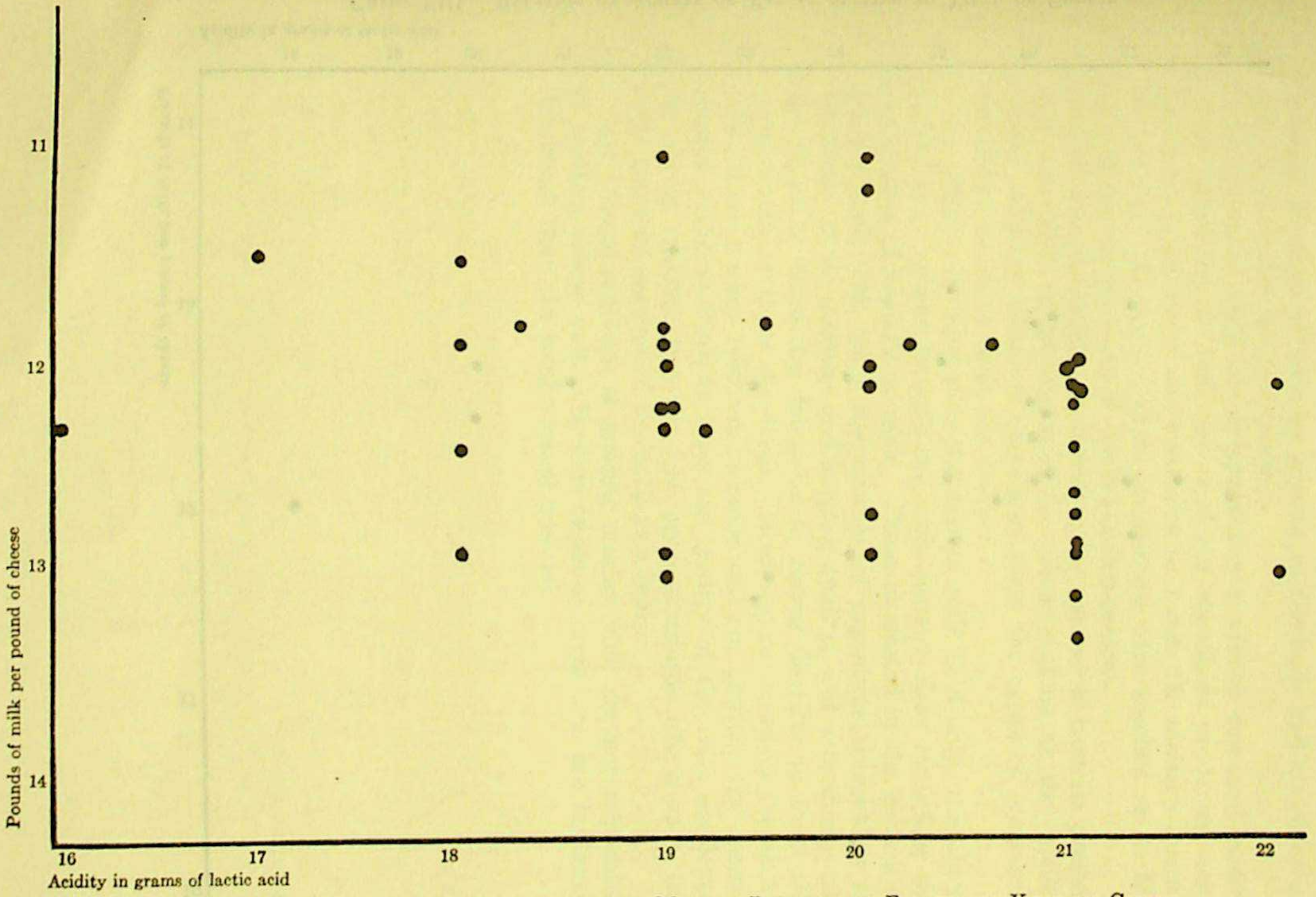

CHART VII.—RELATION OF AVERAGE ACIDITY OF MILK AS RECEIVED AT FACTORY TO YIELD OF CHEESE.

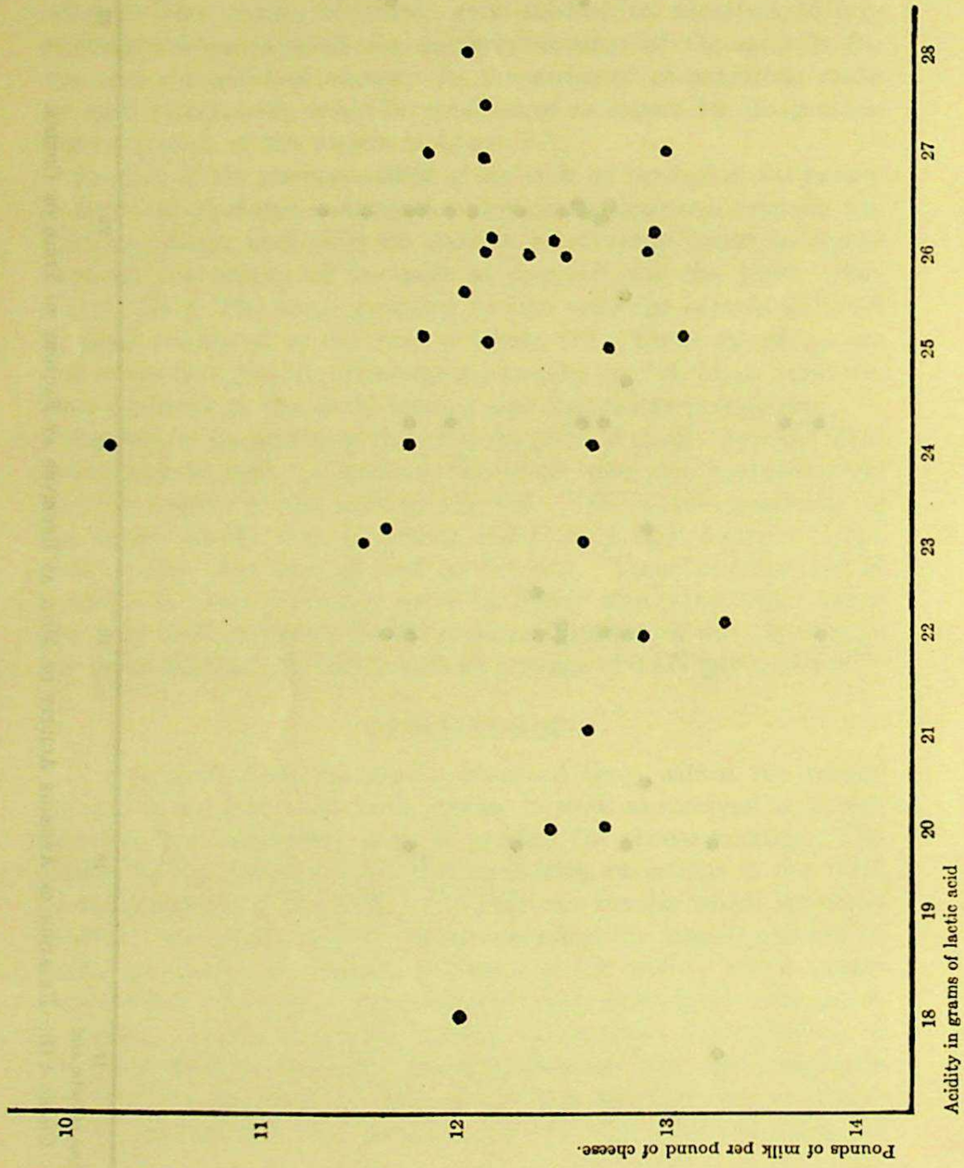

CHART VIII.— RELATION OF ACIDITY OF VAT AT SETTING TO YIELD OF CHEESE.

varying numbers of bacteria present in the milk had no effect on variations in the yield of cheese.

In the above work, the determination of acidity was used merely as an index for the total count of any organisms producing acid. In checking the use of this procedure to denote the sanitary quality of the milk the same general conclusions were reached as in the case of the actual count of the organisms present.

Methods of grading milk based on the number of bacteria present will not apply to grading milk for cheese making as the quality of the resulting cheese is dependent upon the types of organisms present rather than upon the number.

To workers familiar with the market milk field only, the above results may appear inconsistent with current ideas regarding the significance of bacteria in milk. Those interested in the control of market milk look upon the number of organisms present as an indication of its sanitary and keeping quality, and a tendency has developed to force the dairyman in cheese districts to meet the requirements of these standards. However, as shown in the above data, these market-milk requirements will not produce the desired results in cheese districts since the quality of the milk employed for cheese making does not rest upon standards which have the total bacterial content of the milk as a basis.

Our present methods of grading market milk are not applicable to grading cheese milk. Specific types of organisms are far more important than the total number present.

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